CPV Smyth Generation Company, LLC
Smyth County, Virginia

Meteorological Monitoring Plan

Submitted By:
CPV Smyth Generation Company LLC
8403 Colesville Road, Suite 915
Silver Spring, MD 20910

Submitted To:
Virginia Department of Environmental Quality
Division of Air Quality
629 East Main Street
Richmond, VA 23218

Prepared by:
ALL4

Submitted: January 2013
Version 1.0
# TABLE OF CONTENTS

1. INTRODUCTION ................................................................................................................................. 1-1
2. FACILITY AND METEOROLOGICAL MONITORING SITE DESCRIPTION ........................................... 2-1
   2.1 GENERAL TOPOGRAPHIC DESCRIPTION .................................................................................. 2-1
   2.2 MONITORING SITE DESCRIPTION ......................................................................................... 2-3
3. METEOROLOGICAL EQUIPMENT AND MONITORING CONFIGURATION ......................................................... 3-1
   3.1 MULTI-LEVEL METEOROLOGICAL TOWER ........................................................................ 3-1
   3.2 HORIZONTAL WIND SPEED ............................................................................................... 3-2
   3.3 HORIZONTAL WIND DIRECTION ......................................................................................... 3-2
   3.4 VERTICAL WIND SPEED ................................................................................................ 3-7
   3.5 TEMPERATURE ................................................................................................................... 3-7
   3.6 SOLAR RADIATION ........................................................................................................... 3-8
   3.7 BAROMETRIC PRESSURE SENSOR ...................................................................................... 3-8
   3.8 DATA LOGGING SYSTEMS .................................................................................................... 3-9
   3.9 SODAR SYSTEM .................................................................................................................. 3-11
4. QUALITY CONTROL AND QUALITY ASSURANCE ......................................................................................... 4-1
   4.1 QUALITY CONTROL ........................................................................................................... 4-1
       4.1.1 System Design and Equipment Procurement .......................................................... 4-1
       4.1.2 Routine Operating Procedures ................................................................................. 4-2
       4.1.3 Data Validation ......................................................................................................... 4-2
   4.2 QUALITY ASSURANCE ....................................................................................................... 4-5
       4.2.1 Horizontal Wind Speed Audit Procedures .............................................................. 4-6
       4.2.2 Vertical Wind Speed Audit Procedures ...................................................................... 4-7
       4.2.3 Wind Direction Audit Procedures ............................................................................ 4-7
       4.2.4 Temperature Audit Procedures ................................................................................ 4-8
       4.2.5 Barometric Pressure Audit Procedures ..................................................................... 4-9
       4.2.6 Solar Radiation .......................................................................................................... 4-9
       4.2.7 SODAR System .......................................................................................................... 4-10
5. DATA AVAILABILITY ......................................................................................................................... 5-1
6. REFERENCES .......................................................................................................................................... 6-1
LIST OF FIGURES

Figure 2-1  Proposed Facility Location ....................................................................................... 2-2
Figure 2-2  Facility Overhead Photo ............................................................................................ 2-4
Figure 2-3  View Towards the North and East ............................................................................ 2-5
Figure 2-4  View Towards the South and West ........................................................................... 2-6
Figure 3-1  Schematic of Meteorological Tower ......................................................................... 3-5
Figure 3-2  Meteorological Monitoring Site Layout ..................................................................... 3-6
LIST OF TABLES

Table 3-1  Summary of Meteorological Sensors ................................................................. 3-3
Table 3-2  Comparison of U.S. EPA Recommended Response Characteristics, System Accuracy,
and Resolutions to CPV Meteorological Sensor Specifications ........................................ 3-4
Table 3-3  Summary of Primary and Calculated Meteorological Variables ...................... 3-10
Table 3-4  Response Characteristics for the SODAR System ........................................... 3-12
Table 4-1  Monitoring Station Checklist ............................................................................ 4-3
Table 4-2  Data Screening Criteria ..................................................................................... 4-4
1. INTRODUCTION

CPV Smyth Generation Company, LLC (CPV) is proposing to operate an on-site meteorological monitoring system to support a Prevention of Significant Deterioration (PSD) permitting project for their proposed CPV Smyth Energy Center in Atkins, VA. The program is designed to collect one (1) year of data suitable for use with the U.S. EPA AERMOD air dispersion model. The Virginia Department of Environmental Quality (VADEQ) has determined that off-site data at the Mountain Empire Airport Marion/Wytheville (KMKJ) Automated Weather Observation System (AWOS) station are not representative of the proposed CPV Smyth Energy Center site and has therefore requested that CPV collect on-site meteorological data with a 30 meter (m) tower and Doppler Sonic Detection and Ranging (SODAR) system.

On November 29, 2012 CPV, All4 Inc., (ALL4), and Arcadis U.S. Inc. (Arcadis) met with representatives from VADEQ at the proposed CPV Smyth Energy Center site in Atkins, VA to select a location to site the meteorological equipment. The location selected during the November 29, 2012 meeting is presented in this monitoring plan.

In order to confirm that the proposed meteorological monitoring system is designed in a manner acceptable to the VADEQ, this meteorological monitoring plan is being provided to VADEQ. CPV requests that VADEQ review this monitoring plan and confirm that the proposed monitoring system will be acceptable for use in collecting data for the air quality modeling study.

This monitoring plan describes the design, operation, and quality assurance/quality control (QA/QC) measures that will be followed as part of the meteorological monitoring project. This monitoring plan was prepared following U.S. EPA guidance, and contains the following sections:

- Section 2 – Facility and Meteorological Monitoring Site Description
- Section 3 – Meteorological Equipment and Monitoring Configuration
- Section 4 – Quality Control and Quality Assurance
- Section 5 – Data Availability
- Section 6 – References
2. FACILITY AND METEOROLOGICAL MONITORING SITE DESCRIPTION

This section of the meteorological monitoring plan contains a description of the proposed facility and the surrounding terrain. A description of the proposed monitoring site is also provided as well as photographs from the site in all cardinal directions.

CPV is proposing to operate a new 700 megawatt (MW) combined-cycle electric generating facility located in Smyth County, Virginia. The new facility will be located on 108 acres located approximately 50 miles northeast of the Virginia-Tennessee border in Atkins, VA. The emission units at the facility will include the following:

- Two (2) Alstom combustion turbines (CT)
- Two (2) heat recovery steam generators (HRSG)
- One (1) steam turbine (ST)

The facility will operate the turbines using clean-burning natural gas from the East Tennessee Pipeline. An electrical interconnection substation will be located on site to efficiently distribute the electricity produced by the turbines into the local transmission lines.

2.1 GENERAL TOPOGRAPHIC DESCRIPTION

The proposed CPV Smyth Energy Center is located in the town of Atkins, Smyth County in Southwestern Virginia. The proposed CPV Smyth Energy Center is situated just outside of a valley, with elevation changes from 2,300 ft at the valley floor to over 4,000 ft in the surrounding Appalachian Mountains. The valley is generally oriented from the east-northeast to the west-southwest. Areas of complex terrain, elevations that exceed the elevation of the proposed CPV Smyth Energy Center stack tops (i.e. facility base elevation of approximately 2,500 ft plus the proposed stack height of 250 ft, 2,750 ft), occur within one (1) mile of the proposed facility. A USGS 7.5 minute topographical map with the location of the proposed CPV Smyth Energy Center is shown in Figure 2-1.
Based on USGS 1:24,000 Quadrangle map for Atkins, Virginia, 1991.

Figure 2-1
Proposed CPV Smyth Energy Center

CPV Smyth Generation Company, LLC
2.2 MONITORING SITE DESCRIPTION

The proposed monitoring site is in an open field in the center of the proposed CPV Smyth Energy Center. The proposed site is located at a high point in the grassy open field with ground that slopes away to the northwest and southeast. The proposed site is at approximately the same base elevation as the proposed CPV Smyth Energy Center stacks will be, approximately 2,500 ft. The closest obstruction is a private residence located 500 ft northwest at an elevation of 2,425 ft. A forested area is located approximately 100 ft to the northeast and the southwest and 800 feet to the northwest and southeast with trees approximately 30 ft in height. The geographical coordinates for the approximate location of the proposed monitoring site are:

- Universal Transverse Mercator (UTM) Easting: 462,923 meters
- Universal Transverse Mercator (UTM) Northing: 4,079,140 meters
- UTM Zone: 17
- North American Datum (NAD): 1983

An overhead photo of the proposed meteorological monitoring site is shown in Figure 2-2, with the location of the nearby residence and forested areas. The approximate location of the proposed meteorological monitoring equipment is noted. The views from the site to the north and east are shown in Figure 2-3, while the views to the south and west are shown in Figure 2-4.
Based on USGS 1:24,000 Digital Orthoimage Quadrangle (DOQQ) map for northeast Atkins, Virginia, 2011.

Proposed Meteorological Monitoring Site Location
Lat: 36.857451
Long: -81.415944

Figure 2-2
Proposed Meteorological Monitoring Site Location
Figure 2-3
View Towards the North and East

View towards the north

View towards the east
Figure 2-4
View Towards the South and West

View towards the south

View towards the west
3. METEOROLOGICAL EQUIPMENT AND MONITORING CONFIGURATION

The proposed meteorological monitoring system will consist of a tall tower and remote sensing equipment. The tall tower is an integrated system that includes a 30 m meteorological tower, meteorological instrumentation, and datalogging equipment. The remote sensing equipment consists of an acoustic Doppler SODAR system. The meteorological monitoring equipment is designed to make real-time measurements of the meteorological conditions that will be used as input into air quality dispersion models to simulate transport and dispersion of air emissions from the proposed facility. The equipment selected for the proposed monitoring system meets U.S. EPA accuracy criteria and is manufactured by companies with many years of experience in meteorological monitoring for air quality applications. Descriptions of each of the components of the meteorological monitoring system are provided in the following subsections.

3.1 MULTI-LEVEL METEOROLOGICAL TOWER

The multi-level meteorological tower and SODAR wind measurements will be used in the AERMET meteorological processor to generate a vertical profile of wind speed, wind direction, and turbulence parameters for use in the AERMOD air dispersion model. The levels of wind data from the SODAR will be combined with the tower wind data. All valid data collected from the SODAR will be used by AERMET to create the most refined vertical profile possible. CPV believes that the combined use of tower/SODAR meteorological data will be representative of the meteorological conditions, for use in AERMOD dispersion modeling study for the proposed CPV Smyth Energy Center.

Measurements will be made at the 30 m (98 ft) level, the 10 m (33 ft) level, and the 2 m (6.5 ft) level. The 30 m and 10 m instruments will be attached to boom arms. The boom arms will extend out approximately 2.4 m (8 ft) from the edge of the tower, with the instruments mounted at the farthest extent of the arm. The 2.4 m long boom arms will ensure that no wake effects from the lattice construction of the tower will affect the instruments. The instruments at the 2 m level will be attached to a fixed boom extension. The boom arms will be mounted in the general
prevailing wind direction, on the southwest side of the tower which faces the upwind direction of the valley. The tower will be secured by three guy wires, with a guy radius of approximately 30.5 m (100 ft). A weather-proof enclosure for the datalogger that will collect, record, and process the measurements made by meteorological sensors will be mounted to one side of the tower.

A summary of the meteorological sensors to be used on the 30 m meteorological tower are provided in Table 3-1 and the response characteristics for the meteorological sensors are provided in Table 3-2. A schematic of the meteorological tower system is shown in Figure 3-1 and a schematic of the meteorological monitoring site layout is shown in Figure 3-2.

3.2 HORIZONTAL WIND SPEED

Wind speed measurements will be made with a three-cup anemometer. The anemometer consists of a 20 slotted photo-chopper assembly, a light source, and associated electronics. The sensor produces a pulse count that is proportioned to the wind speed. The anemometer is mounted on a crossarm assembly. Cabling connects the anemometer to a data logger that records the wind speed measurements. A heater assembly is attached to the body of the sensor to prevent icing of the cupset assembly. The wind speed sensor to be used for the CPV monitoring program is manufactured by Climatronics. A lexan cupset that is matched to the wind speed sensor will be used. The wind speed sensors will be mounted at the 10 m (33 ft) and the 30 m (98 ft) levels of the tower, facing the direction of the prevailing wind. The 10 m wind speed measurement will serve as the reference wind speed measurement for use by the AERMET meteorological preprocessor.

3.3 HORIZONTAL WIND DIRECTION

Wind direction measurements will be made with a vane that is attached to a potentiometer assembly. A constant voltage is supplied to the potentiometer, and as the vane rotates a different
### Table 3-1
Summary of Meteorological Sensors

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Tower Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Wind Speed</td>
<td>Climatronics Corporation</td>
<td>100075</td>
<td>10m, 30m</td>
</tr>
<tr>
<td>Vertical Wind Speed</td>
<td>Climatronics Corporation</td>
<td>102236</td>
<td>30m</td>
</tr>
<tr>
<td>Wind Direction</td>
<td>Climatronics Corporation</td>
<td>100076</td>
<td>10m, 30m</td>
</tr>
<tr>
<td>Ambient Temperature</td>
<td>Climatronics Corporation</td>
<td>100093</td>
<td>2m, 10m, 30m</td>
</tr>
<tr>
<td>Solar Radiation</td>
<td>Kipp &amp; Zonen</td>
<td>CMP 3</td>
<td>2m</td>
</tr>
<tr>
<td>Barometric Pressure</td>
<td>Setra</td>
<td>276</td>
<td>2m</td>
</tr>
<tr>
<td>Datalogger</td>
<td>Campbell Scientific</td>
<td>CR1000</td>
<td>N/A</td>
</tr>
<tr>
<td>F460 Crossarm</td>
<td>Climatronics Corporation</td>
<td>101994</td>
<td>10m, 30m</td>
</tr>
<tr>
<td>Base Connector Assembly Vertical Wind Sensor</td>
<td>Climatronics Corporation</td>
<td>102234</td>
<td>30m</td>
</tr>
<tr>
<td>Motor Aspirated Temperature Shield</td>
<td>Climatronics Corporation</td>
<td>100325</td>
<td>2m, 10m, .0m</td>
</tr>
</tbody>
</table>
# Table 3-2
Comparison of U.S. EPA Recommended Response Characteristics, System Accuracy, and Resolutions to CPV Meteorological Sensor Specifications

<table>
<thead>
<tr>
<th>Sensor (Meteorological Variable)</th>
<th>Sensor Variable</th>
<th>Recommended U.S. EPA System Response Characteristics (a)</th>
<th>System Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Wind Speed</td>
<td>Starting Threshold Distant Constant Accuracy (b) Measurement Resolution</td>
<td>≤ 1.1 mph ≤ 16.4 ft. ± 0.45 mph + 5% of observed 0.2 mph</td>
<td>0.5 mph &lt; 13.1 ft. ± 0.15 mph or ± 1.0% of observed 0.1 mph</td>
</tr>
<tr>
<td>Vertical Wind Speed</td>
<td>Starting Threshold Distant Constant Accuracy (b) Measurement Resolution</td>
<td>≤ 1.1 mph ≤ 16.4 ft. ± 0.45 mph + 5% of observed 0.2 mph</td>
<td>0.5 mph 8 ft. ± 0.25 mph or 1.6% of observed 0.1 mph</td>
</tr>
<tr>
<td>Wind Direction</td>
<td>Starting Threshold Distant Constant Accuracy (b) Damping Ratio Measurement Resolution</td>
<td>≤ 1.1 mph at 10° deflection ≤ 16.4 ft. ± 5 degrees 0.4 to 0.7 1 degree</td>
<td>0.5 mph &lt; 8.2 ft. ± 2 degrees &gt; 0.4 at 10° initial angle of attack 0.3 degree</td>
</tr>
<tr>
<td>Ambient Temperature</td>
<td>Time Constant Accuracy (b) Measurement Resolution</td>
<td>≤ 1 minute ± 0.9 °F 0.18 °F</td>
<td>3.6 seconds ± 0.27 °F 0.02 °F</td>
</tr>
<tr>
<td>Vertical Temperature Difference</td>
<td>Time Constant Accuracy (b) Measurement Resolution</td>
<td>≤ 1 minute ± 0.18 °F 0.036 °F</td>
<td>3.6 seconds ± 0.27 °F 0.036 °F</td>
</tr>
<tr>
<td>Solar Radiation</td>
<td>Time Constant Accuracy (b) Measurement Resolution</td>
<td>≤ 5 seconds ± 5% of observed 10 Watts/square meter 285 to 2,800 nanometers</td>
<td>≤ 18 seconds (c) ± 10% 0.1 W/m² 310 to 2,800 nanometers</td>
</tr>
<tr>
<td>Barometric Pressure</td>
<td>Accuracy (b) Measurement Resolution</td>
<td>± 0.09 inches of Hg 0.01 inches of Hg</td>
<td>± 0.04 inches of Hg 0.003 inches of Hg</td>
</tr>
</tbody>
</table>


(b) The data logger accuracy is 0.1% of the full-scale voltage. It has been included as part of the system accuracy specifications.

(c) The time constant shown for the solar radiation sensor represents the time required by the sensor to respond to 95% of the actual solar radiation rather than 63% of the actual solar radiation proposed by U.S. EPA.
100 ft Level
1.) Horizontal Wind Speed
2.) Vertical Wind Speed
3.) Wind Direction
4.) Temperature

33 ft Level
1.) Horizontal Wind Speed
2.) Wind Direction
3.) Temperature

6.5 ft Level
1.) Temperature
2.) Solar Radiation
3.) Barometric Pressure

Figure 3-1
Schematic of Proposed Meteorological Tower
(Not to Scale)
MET Tower Schematic

CPV
Smyth Energy Center
Atkins, VA

~ 1/16” = 1’
voltage is produced that corresponds to the direction from which the wind is blowing. The wind direction sensor is mounted at the opposite end of the crossarm assembly from the wind speed sensor. The sensor will be oriented so that when the vane is aligned along the length of the crossarm a reading of one of the cardinal directions will be obtained (i.e., north, south, east, west). A heater assembly will be attached to the body of the wind sensor to reduce the potential for icing of the vane to occur. The wind direction sensors will be mounted at the 10 m (33 ft) and the 30 m (98 ft) levels of the tower, facing the direction of the prevailing wind.

3.4 **VERTICAL WIND SPEED**

Vertical wind speed measurements will be made with a propeller driven wind speed sensor. The anemometer consists of a 20 slotted photo-chopper assembly, a light source, and associated electronics. The sensor produces a pulse count that is proportioned to the wind speed. Clockwise rotation of the propeller will correspond to updraft or positive vertical wind speed while counter-clockwise rotation of the propeller will correspond to downdraft or negative vertical wind speed. The vertical wind speed sensor will be mounted on the center of the crossarm assembly. Cabling connects the anemometer to a data logger that records the wind speed measurements. A heater assembly is attached to the body of the sensor to prevent icing of the propeller. The vertical wind speed sensor to be used for the CPV monitoring program is manufactured by Climatronics. The propeller is constructed of expanded polystyrene and is matched to the vertical wind speed sensor. The vertical wind speed sensor will be mounted at the 30 m (98 ft) level of the tower.

3.5 **TEMPERATURE**

Temperature measurements will be made using a dual thermistor sensor. The thermistors are encased in a stainless steel sheath. A constant voltage is supplied to the two (2) thermistors, and when two (2) precision resistors are wired with the thermistor a linear relationship between voltage and temperature is obtained. The temperature sensor is housed in a motor aspirated
shield that provides a constant airflow over the sensor, eliminating any effect that direct solar heating may have on the measurement process. Signal cabling connects the sensor to the data logging system. The temperature sensor and motor aspirated sheath are manufactured by Climatronics.

3.6 SOLAR RADIATION

A Kipp and Zonen CMP3 pyranometer will be used to make solar radiation measurements. The pyranometer uses a photo-voltaic measurement to determine the amount of short-wave radiation (shortwave radiation with a wavelength between 310 and 2,800 nanometers). The sensor produces a voltage that is proportional to the solar radiation in watts per square meter (W/m²). The solar radiometer is connected via cabling to the data logger. Specific data logger program instructions have been supplied by Kipp and Zonen and will be used in the data logger. The solar radiometer will be mounted to the south of the tower at a height of 2 m (6.6 ft) and will have a natural surface underneath it. The sensor will be sited away from any obstruction that could cast shadows.

3.7 BAROMETRIC PRESSURE SENSOR

An analog sensor will be used to make barometric pressure measurements. The sensor is manufactured by Climatronics and uses an Application Specific Integrated Circuit (ASIC) that works with a capacitive transducer to measure pressure. The sensor will be mounted in a weatherproof housing and cabling will connect the sensor to the data logger. The sensor will be mounted at the 2 m (6.5 ft) level.
3.8 DATA LOGGING SYSTEMS

A Campbell Scientific data logger will be used to record the measurements made by the meteorological sensors. The Campbell CR1000 data logger will scan and store the output of each sensor once per second and calculate five (5) minute and hourly averages. The accuracy of the CR1000 is 0.1% of the voltage range used to measure each meteorological variable.

In addition to recording, storing, and averaging the primary meteorological variables, the CR1000 data logger will compute derived meteorological variables such as delta temperature, surface roughness, peak wind gust, standard deviation of wind direction (sigma theta), and standard deviation of vertical wind speed (sigma W). The calculation of the derived meteorological variables will follow U.S. EPA guidelines (U.S. EPA 2000) except that 300 observations (i.e., 60 one (1) second averages per minute times five (5) minutes per averaging period) will be used to calculate the derived meteorological variables instead of 360 observations. The use of 300 observations will not affect the accuracy or precision of any of the calculated meteorological variables. A summary of the primary and calculated meteorological measurements and the units and averaging periods that will be recorded in the data logger is shown in Table 3-3.

The CR1000 data logger will be linked to a cellular phone modem. The cellular phone modem will allow real time and routine access to the meteorological data via the cellular phone network. The CR1000 data logger has four (4) megabytes (mb) of internal memory which is sufficient to hold one (1) month of data in the event that communication is lost. The CR1000 data logger operates on 12 volts direct current (dc). A trickle charge battery is used to supply power to the data logger. The trickle charge battery is connected to alternating current (ac) power, but will supply power to the data logger for several days if ac power is lost. The CR1000 data logger and associated peripherals will be mounted in a weather proof enclosure.
## Table 3-3
### Summary of Primary and Calculated Meteorological Variables

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Measurement Type</th>
<th>Units</th>
<th>Averaging Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Wind Speed</td>
<td>Primary</td>
<td>Miles Per Hour (mph)</td>
<td>5-minute, 1-hour</td>
</tr>
<tr>
<td>Standard Deviation of the Wind Speed</td>
<td>Calculated</td>
<td>Miles Per Hour (mph)</td>
<td>5-minute, 1-hour</td>
</tr>
<tr>
<td>Vertical Wind Speed</td>
<td>Primary</td>
<td>Miles Per Hour (mph)</td>
<td>5-minute, 1-hour</td>
</tr>
<tr>
<td>Standard Deviation of the Vertical Wind Speed (Sigma W)</td>
<td>Calculated</td>
<td>Miles Per Hour (mph)</td>
<td>5-minute, 1-hour</td>
</tr>
<tr>
<td>Wind Direction</td>
<td>Primary</td>
<td>Degrees (°)</td>
<td>5-minute, 1-hour</td>
</tr>
<tr>
<td>Standard Deviation of the Wind Direction (Sigma Theta)</td>
<td>Calculated</td>
<td>Degrees (°)</td>
<td>5-minute, 1-hour</td>
</tr>
<tr>
<td>Ambient Temperature</td>
<td>Primary</td>
<td>Degrees Fahrenheit (°F)</td>
<td>5-minute, 1-hour</td>
</tr>
<tr>
<td>Solar Radiation</td>
<td>Primary</td>
<td>Watts Per Meter Squared (W/m²)</td>
<td>5-minute, 1-hour</td>
</tr>
<tr>
<td>Barometric Pressure</td>
<td>Primary</td>
<td>Millibar (mb)</td>
<td>5-minute, 1-hour</td>
</tr>
<tr>
<td>Surface Roughness</td>
<td>Calculated</td>
<td>Meters (m)</td>
<td>5-minute (a)</td>
</tr>
<tr>
<td>Maximum Wind Speed</td>
<td>Primary</td>
<td>Miles Per Hour (mph)</td>
<td>3-second</td>
</tr>
</tbody>
</table>

(a) Surface roughness is only calculated when the wind speed is greater than 11.18 mph based on the gustiness equation 6.4.2 in “On-Site Meteorological Program Guidance for Regulatory Modeling Applications,” EPA-450/4-87-013, June (1987).
3.9 SODAR SYSTEM

An Atmospheric Systems Corporation (ASC) 4000F miniSODAR will be used for the CPV meteorological monitoring program. The miniSODAR uses a single electronically-steered speaker array to generate acoustic pulses. The speaker array is surrounded by a fiberglass enclosure. The enclosure is heated to avoid the accumulation of snow and ice. An electronic control box is connected to the antenna portion of the SODAR and contains the electronics, computer and software that interpret the signals received from the antenna.

The SODAR will make wind measurements much higher than the proposed stack top elevation, up to 250 m into the atmosphere. This is important since the proposed CPV Smyth Energy Center is situated in complex terrain and U.S. EPA guidance recommends that measurements should be made up to plume rise height of interest. The SODAR system will be used to collect multi-level measurements of wind speed (horizontal and vertical), wind directions, and turbulence. The response characteristics for the SODAR system are provided in Table 3-4.

The operating principle of the SODAR system consists of transmitting a pulse of acoustic energy into the atmosphere vertically and at angles from the vertical. As the wave propagates upward, differences in atmospheric density due to small-scale temperature differences cause some energy to be scattered back to the surface. The returned energy is received by the antenna and the frequency of the signal and the times of transmission are determined. The difference between the transmitted and received frequencies (known as the Doppler shift) is directly proportional to the wind velocity along the beam axis. The difference in time between the transmitted and received signal, and the speed of sound is then used to calculate the altitude from which the signal is received.

The SODAR will be located in an open, level area. The beams from the speakers will be pointed away from any obstructions which would interfere with the operation of the SODAR system such as the meteorological tower, electric transmission lines, buildings and trees, and the SODAR support trailer.
Table 3-4
Response Characteristics for the SODAR System

<table>
<thead>
<tr>
<th>Meteorological Variable</th>
<th>Specification</th>
<th>Design Characteristic</th>
<th>U.S. EPA Guidelines (a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Wind Speed</td>
<td>Range, Accuracy, Height Range, Height Resolution, Average Period</td>
<td>0 to 50 m/s, &lt;0.50 m/s, 10 to 250 m, 5 m, 30 seconds to 1 hour</td>
<td>Not Applicable, ≤(±0.2 m/s), Not Applicable, Not Applicable, Not Applicable</td>
</tr>
<tr>
<td>Wind Direction</td>
<td>Range, Accuracy, Height Range, Height Resolution, Average Period</td>
<td>0 to 359 degrees, ±5 degrees, 10 to 250 m, 5 m, 30 seconds to 1 hour</td>
<td>Not Applicable, ±5 degrees, Not Applicable, Not Applicable</td>
</tr>
</tbody>
</table>

The SODAR system will provide the following information in 15 m height increments from 10 m up to 250 m above local grade:

- Vector Wind Speed
- Vector Wind Direction
- Sigma Theta
- Vector Vertical Wind Speed
- Sigma W

Data recovery for the program should be at least 90 percent (%) for the variables in the lowest levels of the atmosphere. At higher heights, environmental variables such as background noise and weather conditions may reduce the data recovery rates. All data variables will be recorded in 15-minute time intervals. An hour will be considered valid if three (3) 15-minute blocks are collected per level. No restrictions will be placed on the number of levels of data recovered per hour.

It should be noted that the 15-minute block vector quantities will be averaged to generate scalar hourly averages. To accomplish the hourly averages, the averaging routines described in U.S. EPA 2000 will be used. By using scalar hourly averages for the SODAR data there will be consistency between the hourly SODAR data and 30 m meteorological tower data.
4. QUALITY CONTROL AND QUALITY ASSURANCE

An extremely important component to the CPV meteorological monitoring program will be the institution of a quality control and quality assurance program. The quality control program will be designed to ensure that the meteorological monitoring program operates without significant loss of data due to malfunctioning equipment or other operational problems and meets a 90% data recovery rate. The quality assurance program is designed to demonstrate that the meteorological measurements meet U.S. EPA accuracy criteria. This section of the monitoring plan describes the specific quality control and quality assurance procedures that will be followed.

4.1 QUALITY CONTROL

Quality control consists of routine practices that are designed to ensure that accurate and precise measurements are being made. Quality control begins with the design of the monitoring system, procurement of equipment, implementation of routine operating procedures that maintain the monitoring program, and instituting rigorous data validation steps. The quality control procedures for the meteorological tower and SODAR system will follow the U.S. EPA procedures (U.S. EPA 2000 and 2008). The quality control procedures and the approach to data validation are outlined in the following subsections.

4.1.1 System Design and Equipment Procurement

The meteorological monitoring program has been designed by qualified meteorologists who have experience operating meteorological monitoring programs. As explained in previous sections of this monitoring plan, the meteorological monitoring system will be installed to meet U.S. EPA siting and design criteria. The meteorological equipment to be used for the CPV monitoring program will undergo manufacturer recommended inspection prior to being used, and will be initially calibrated upon installation. An inventory of spare equipment will be maintained to reduce data loss if a sensor is damaged or malfunctions.
4.1.2 Routine Operating Procedures

Routine operating procedures will consist of on-site tasks and off-site tasks that are completed regularly. The on-site tasks will include start-up field calibrations and as needed special inspections. The start-up calibration will be performed by project team members who are responsible for the installation of the monitoring equipment. An on-site technician will be trained by experienced project team member to perform physical inspections of the meteorological monitoring equipment. The on-site technician will complete the site checklist, shown in Table 4-1, during each site visit. The off-site tasks will include daily reviewing of data, archiving of data, and reporting of data.

4.1.3 Data Validation

The meteorological data from the 30 m tower and SODAR will be reviewed on a daily basis (Monday through Friday) by a project team member. The data will be edited to remove any invalid data. Quarterly report summaries will be prepared and the meteorological data will then be archived.

Hourly data from the meteorological tower will be reviewed for hour-by-hour trends and for consistency with known meteorological conditions for the region. The data will be compared to the screening criteria that are listed in Table 4-2. Additionally, the on-site data will be routinely compared with the meteorological data from the KMKJ AWOS station. The KMKJ AWOS station data will be obtained via the internet and will be used for very general data comparison due to the difference in monitoring locations. The on-site field notes will be reviewed routinely to determine if any meteorological data need to be invalidated. In the event that invalid data are present during an hourly period, the invalid five (5)-minute averages will be removed from the meteorological database and the remaining five (5)-minute values will be re-averaged for an hourly average. If four or more five (5)-minute periods are invalid (i.e. 20 minutes of invalid data) the entire hour will be invalidated. U.S. EPA guidance for data averaging (U.S. EPA 2000) will be used.
<table>
<thead>
<tr>
<th>Monitoring Station Checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Date</strong></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Table 4-2  
Data Screening Criteria

Wind Speed (Horizontal and Vertical)
- is less than zero or greater than 25 m/s
- does not vary by more than 0.1 m/s for 3 consecutive hours
- does not vary by more than 0.5 m/s for 12 consecutive hours

Wind Direction
- is less than zero or greater than 360 degrees
- does not vary by more than 1 degree for more than 3 consecutive hours
- does not vary by more than 10 degrees for 18 consecutive hours

Temperature
- is greater than the local record high
- is less than the local record low
  (the above limits could be applied on a monthly basis.)
- is greater than a 5° C change from the previous hour
- does not vary by more than 0.5 °C for 12 consecutive hours

Temperature Difference
- is greater than 0.1 °C/m during the daytime
- is less than -0.1 °C/m during the night time
- is greater than 5.0 °C or less than -3.0 °C
- is greater than a 5 °C change from the previous hour
- does not vary by more than 0.5 °C for 12 consecutive hours
- equals zero for 12 consecutive hours

Pressure
- is greater than 1060 millibar (mb) (corrected to sea level)
- is less than 940 mb (corrected to sea level)
- changes by more than 6 mb in three hours

Solar Radiation
- is zero at night
- is greater than 20 W/m² during the day
- is greater than the maximum possible for the date and latitude
On a daily basis (Monday through Friday), a project team member who is familiar with SODAR operations will review the SODAR data and perform a comparison to the meteorological tower data for overall consistency. Comparisons of the data will take into account the meteorological conditions, differences due to sampling techniques, and differences in measurement height. Data validation checks will include checking for unreasonable wind speeds, false echoes, and noise interferences. SODAR data that are suspect will be flagged for additional review. All adjustments, deletions, or modifications will be recorded with a justification or reason for the change.

The computer system and SODAR control system reduce the data from the antenna into 15-minute averages. The four 15-minute data blocks will then be averaged by a program to produce hourly average values. A valid hour of SODAR data will contain at least three 15-minute average data blocks.

All practical steps will be taken to achieve a 90% data recovery rate for the SODAR levels of interest (i.e., stack top and plume elevations). However, it should be noted that data recovery rates of less than 90% should not adversely affect the quality of the meteorological measurements since AERMOD uses a profile of atmospheric conditions to determine plume transport and dispersion. Consequently, the more meteorological information that is available, even if it is less than 90% complete, will only improve the model’s ability to make realistic predictions of ambient air concentrations.

4.2 QUALITY ASSURANCE

This section of the monitoring plan describes the specific procedures that will be followed to conduct quality assurance checks (i.e., audits) of the CPV meteorological monitoring system. The quality assurance audit will include a performance audit and a systems audit. The performance audit will evaluate the ability of the meteorological sensors to make accurate measurements. The systems audit will evaluate the procedures that are routinely followed to ensure the quality of the data. The specific steps that will be followed as part of the quality
assurance audit are based on recommendations contained in the U.S. EPA “Quality Assurance Handbook for Air Pollution Measurement Systems Volume IV – Meteorological Measurements” (U.S. EPA, 2008). The audits will be performed semi-annually at the six (6) month and 12 month marks, by an independent project team member who is not involved with the routine operation and calibration.

The meteorological sensors at the Smyth Energy Center site will be audited using artificial fields (e.g. a National Institute of Standards [NIST] certified synchronous motor, linearity test fixture) and/or transfer standards (e.g., NIST certified temperature probe, and solar radiation sensor). Each audit of a meteorological sensor will be conducted for a five (5) to 15-minute period so that a stable response will be produced. The results for each sensor will be based upon the data logger system outputs, thereby auditing the entire meteorological monitoring system from meteorological sensor to data logger processing.

### 4.2.1 Horizontal Wind Speed Audit Procedures

The wind speed audit will test the accuracy of the wind speed sensor over a range of wind speed conditions. A direct current (dc) voltage motor will be used to generate a known rate of rotation that corresponds to a known wind speed. For the horizontal wind speed sensors, the motor will be attached to the shaft of the sensor and the sensor’s response will be monitored. Multiple rates of rotation and a zero rotation per minute (rpm) setting will be used to audit the wind speed sensor. The differences between the known wind speeds and the response wind speeds will be compared to the U.S. EPA accuracy criteria of ±0.45 mile per hour (mph).

In addition to testing the accuracy of the wind speed sensors, a torque wheel will be used to qualitatively measure the starting threshold of the wind speed sensor (i.e., the lowest wind speed at which the sensor will physically operate). The torque wheel will be attached to the shaft of the sensors and 0.1 gram (g) weights will be applied at 1 centimeter (cm) intervals from the center of the torque wheel. The resulting torque (g-cm) will give a qualitative indication of the starting
wind speed threshold. The starting torque will be compared to the manufacturer’s sensor specification to give a qualitative assessment of the starting wind speed.

4.2.2 Vertical Wind Speed Audit Procedures

The vertical wind speed audit will test the accuracy of the vertical wind speed sensor over a range of wind speed conditions. A dc voltage motor will be used to generate a known rate of rotation that corresponds to a known wind speed. Multiple rates of rotation in both directions (i.e., clockwise rotation and counter-clockwise rotation) and a zero rpm setting will be used to audit the wind speed sensor. The differences between the known wind speeds and the response wind speeds will be compared to the U.S. EPA accuracy criteria of ±0.45 mile mph.

In addition to testing the accuracy of the vertical wind speed sensor, a torque wheel will be used to measure qualitatively the starting threshold of the wind speed sensor (i.e. the lowest wind speed at which the sensor will physically operate). The torque wheel will be attached to the shaft of the sensor and 0.1 g weights will be applied at 1 centimeter (cm) intervals from the center of the torque wheel. The resulting torque (g-cm) will give a qualitative indication of the starting wind speed threshold. The starting torque will be compared to the manufacturer’s sensor specification to give a qualitative assessment of the starting vertical wind speed.

4.2.3 Wind Direction Audit Procedures

The wind direction audit will include procedures to determine the accuracy of the alignment of the wind direction sensors and the linearity of the sensors. The combined error for alignment and linearity will be compared to U.S. EPA criterion to determine if the sensors are operating within an acceptable limit. The acceptable limit is ± 5 degrees (°).

The absolute alignment of the wind direction sensors will be determined by siting a north monument using the local solar noon method. Once this monument is in place, the alignment of the tower crossarms will be determined by calibrating a field compass to the known monument.
After the true directions for the crossarms are determined, the vanes of the respective wind direction sensor will be aligned along the crossarm and the response will be recorded and compared to the known direction of the crossarm.

A linearity test fixture will be used to determine whether the recorded change in wind direction is linear over a range of wind directions. A linearity test fixture will be attached to the shaft of the wind direction sensor and a starting wind direction will be recorded. The test fixture will then be used to rotate the shaft of the wind direction sensor by a known number of degrees (typically 90°). The rotated direction will be subtracted from the starting wind direction and the difference will be compared to the expected difference (typically 90°). This approach will then be repeated for three additional points. The difference for each point will be used to determine a linearity difference. For each linearity difference, the crossarm alignment error will be added and the combined results will be compared to the U.S. EPA accuracy criterion of ± 5°.

In addition to the alignment and linearity error, the starting threshold of the wind direction sensor will be qualitatively determined in a fashion similar to the wind speed sensors. A torque wheel will be attached to the shaft of the wind direction sensors and 1.0 g weights will be applied at 1 cm intervals from the center of the torque wheel. The resulting torque (g-cm) will give a qualitative indication of the starting wind direction threshold. The starting torque will be compared to the manufacturer’s sensor specification to give a qualitative assessment of the wind speed at which the wind direction sensor will begin to respond.

### 4.2.4 Temperature Audit Procedures

The accuracy of the temperature sensors will be determined at three (3) temperatures. A warm water bath, an ambient water bath, and an ice bath will be used with a NIST calibrated thermometer to test the temperature sensor’s accuracy. The temperature sensors will be placed in an insulated thermos containing an ice bath and allowed to equilibrate before a response is recorded. The same approach will be used for a warm water and ambient bath. Distilled water
will be used for the ice and warm water baths. The U.S. EPA accuracy limit for temperature measurement is ±0.9 degrees Fahrenheit (°F).

In addition to auditing the ambient temperature sensor, the delta temperature calculation between the 2 m, 10 m, and 30 m sensors will also be audited. The delta temperature audit will be performed by immersing the 2 m, 10 m, and 30 m sensors in the water bath and then comparing the differences between the responses. For the delta temperature responses, the 2 m temperature will be subtracted from the 10 m and 30 m temperatures. The U.S. EPA criterion for delta temperature measurements is ±0.18 °F.

### 4.2.5 Barometric Pressure Audit Procedures

The barometric pressure audit will consist of a side-by-side comparison between the site barometric pressure sensor and an independent sensor. The barometric pressure audit will be conducted over several hours. A comparison will be made between the audit points collected by the audit sensor and the corresponding values measured by the site sensor. The difference will be compared to the U.S. EPA acceptance criterion of ±3 millibars (mb) or ±0.09 inches of mercury (in Hg).

### 4.2.6 Solar Radiation

The solar radiation audit will be conducted by making side-by-side comparisons between the site solar radiation sensor and an independent sensor with a NIST calibration. The independent audit sensor will be connected to an audit Campbell Scientific data logger. The solar radiation audit will be conducted over several hours so that a meaningful number of five (5)-minute measurement periods are available. A comparison will be made between the five (5)-minute data collected by the audit sensor and the site sensor. A percent difference will be calculated for each five (5)-minute period and all of the percent differences will be averaged and compared to the
U.S. EPA acceptance criterion of ±5%. Periods with low solar radiation totals (i.e. solar radiation less than 30 W/m²) will be excluded from the audit to avoid biasing the results.

4.2.7 SODAR System

SODAR systems similar to the ASC MiniSODAR that will be used for the CPV monitoring program, have undergone multiple inter-comparison studies with tower based measurements systems to confirm a SODAR system’s ability to make valid measurements. Therefore, the necessity to perform rigorous quality assurance checks (e.g. tethersonde balloon audits) is less important. However, the 30 m tower measurements will be compared to the 30 m SODAR measurements on a routine basis to quality assure the SODAR data. The data comparison will included an average difference in wind speed and wind direction measurements between the two (2) systems.

After each bi-annual meteorological tower audit, a 48-hour block of tower and SODAR data will be compared. The data comparison will be performed on 15-minute averages as well as hourly averages. Data from the two closest SODAR levels will be compared to the 30 m tower data. The SODAR data will be evaluated in terms of bias and comparability.

It should be noted that there are inherent differences between the measured meteorological values from a tower and a SODAR. The SODAR collects wind speed (horizontal and vertical) and wind direction measurements for a volume of air that is five (5) m deep and centered on the pre-set SODAR levels. The meteorological tower measurements are collected at a single height. Also, the meteorological tower measurements are scalar measurements while the SODAR measurements are vector quantities. The difference in the measurement techniques (point versus volume, single height versus a five (5) m layer), and the measurement quantities (scalar versus vector) result in a performance audit that provides a reference check rather than a definitive accuracy check of the system.
5. DATA AVAILABILITY

All data collected during the CPV meteorological monitoring program will be available for review by VADEQ. Over the course of the one (1) year monitoring program, CPV will provide quarterly summaries of the meteorological data to VADEQ. Items that will be available for review include: site calibration records, audit records, site log notes, and raw and edited data files. The data that are collected will be maintained for a minimum of five (5) years in raw format. The meteorological data collected by CPV are proprietary and should not be released to other parties without the consent of CPV.
6. REFERENCES


